IN THE CLAIMS

Claims 1-33 are pending in the application. In order to place promptly the application in a condition for allowance, Applicants cancel claims 1-10 without prejudice. Applicants reserve the right to present these claims in a subsequent continuation or continuation-in-part application.

Claim 11 is now written in independent form and includes all the limitations of Claim 1. Therefore, it is respectfully submitted that the amended Claim 11 is now in allowable form. Furthermore, because Claim 11 is now in an allowable form, dependent claims 12-15 are also now allowable. The applicants thank the Examiner for indicating that the remaining Claims 16-33 are allowable.

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims

We claim:

1. (Cancelled)
2. (Cancelled)
3. (Cancelled)
4. (Cancelled)
5. (Cancelled)
6. (Cancelled)
7. (Cancelled)
8. (Cancelled)
9. (Cancelled)

10. (Cancelled)

11. (Currently Amended) An interlace-to-progressive scan conversion system, comprising:

a prefilter having a prefiltered signal as an output;

a motion estimator having the prefiltered signal as input and a motion-corrected signal as an output;

an adaptive filter having the prefiltered signal and the motion-corrected signal as inputs;~~The interlace-to-progressive scan conversion system of claim 1,~~ wherein:

the adaptive filter comprises a three-stage adaptive recursive filter, wherein:

a first stage comprises a function that selects between using static pixels data and moving pixels data from a next field;

a second stage comprises a function that selects a more valid set of data between motion compensated data from a previous field and the pixels selected by the first stage; and

a third stage comprises a function that combines an intra-field interpolation with the more valid set of data selected by the second stage.

12. (Original) The interlace-to-progressive scan conversion system of claim 11, wherein the prefilter comprises a spatial line average filter.

13. (Original) The interlace-to-progressive scan conversion system of claim 11, wherein the motion estimator comprises a 3-D recursive search sub-component.

14. (Original) The interlace-to-progressive scan conversion system of claim 11, wherein the motion estimator comprises a motion vector correction sub-component.

15. (Original) The interlace-to-progressive scan conversion system of claim 11, wherein the motion estimator comprises a block erosion sub-component.

16. (Original) An interlace-to-progressive scan conversion system, comprising:

a spatial line averaging prefilter having a prefiltered signal as an output;

a motion estimator having the prefiltered signal as input and a motion-corrected signal as an output, the motion estimator comprising:

a 3-D recursive search sub-component;

a motion vector correction sub-component;

a block erosion sub-component;

a three-stage adaptive recursive filter, wherein:

a first stage comprises a function that selects between using static pixels data and moving pixels data from a next field;

a second stage comprises a function that selects a more valid set of data between motion compensated data from a previous field and the pixels selected by the first stage; and

a third stage comprises a function that combines an intra-field interpolation with the more valid set of data selected by the second stage.

17. (Original) The interlace-to-progressive scan conversion system of claim 16, wherein the 3-D recursive search sub-component resolves motion vectors to at least quarter-pixel accuracy.

18. (Original) The interlace-to-progressive scan conversion system of claim 17, wherein the look-up table consists of:

$$US_n = \left\{ \begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 0 \\ 1 \end{pmatrix}, \begin{pmatrix} 0 \\ -1 \end{pmatrix}, \begin{pmatrix} 1 \\ 0 \end{pmatrix}, \begin{pmatrix} -1 \\ 0 \end{pmatrix}, \begin{pmatrix} 0 \\ 2 \end{pmatrix}, \begin{pmatrix} 0 \\ -2 \end{pmatrix}, \begin{pmatrix} 3 \\ 0 \end{pmatrix}, \begin{pmatrix} -3 \\ 0 \end{pmatrix}, \begin{pmatrix} 0 \\ \frac{1}{4} \end{pmatrix}, \begin{pmatrix} 0 \\ -\frac{1}{4} \end{pmatrix}, \begin{pmatrix} \frac{1}{4} \\ 0 \end{pmatrix}, \begin{pmatrix} -\frac{1}{4} \\ 0 \end{pmatrix} \right\}$$

19. (Original) The interlace-to-progressive scan conversion system of claim 16, wherein the motion estimator includes a bilinear interpolator.

20. (Original) The interlace-to-progressive scan conversion system of claim 19, wherein a value of a first estimator is set to a value of a second estimator if:

$$e(\overline{MV}_a, \overline{X} - \overline{SMV}_a, t) > e(\overline{MV}_b, \overline{X} - \overline{SMV}_b, t) + Th$$

and wherein the value of the second estimator is set to the value of the first estimator if:

$$e(\overline{MV}_b, \overline{X} - \overline{SMV}_b, t) > e(\overline{MV}_a, \overline{X} - \overline{SMV}_a, t) + Th$$

where Th is a fixed threshold.

21. (Original) The interlace-to-progressive scan conversion system of claim 16, wherein an error function of the motion estimator includes penalties related to a length of the difference vector between a given candidate vector and a plurality of neighboring vectors.

22. (Original) The interlace-to-progressive scan conversion system of claim 21, wherein the error function is defined by:

$$e(\overline{C},x,y,t) = \sum_{x \in B(x,y,t)} \left| F(x,y,t) - F(x-C_x, y-C_y, t-T) \right| + \alpha \cdot \left\| \overline{U}(x,y,t) \right\|$$

23. (Original) The interlace-to-progressive scan conversion system of claim 21, wherein the motion estimator assumes that a motion vector for an object between a previous field and a current field is the same as a motion vector for the object between the current field and a next field.

24. (Original) The interlace-to-progressive scan conversion system of claim 23, wherein a motion vector error correction function is defined by:

$$\overline{MV}(x,y,t) = \begin{cases} \begin{pmatrix} 0 \\ 0 \end{pmatrix}, & \left(e_m(x,y,t) \geq e_s(x,y,t)\right) \\ \overline{MV}(x,y,t), & \left(e_m(x,y,t) < e_s(x,y,t)\right) \end{cases}$$

where:

$$e_m(x,y,t) = \frac{\sum_{x \in X} |F(X) - F(C)| + \sum_{x \in X} |F(X) - F(D)|}{2}$$

$$e_s(x,y,t) = \frac{\sum_{x \in X} |F(X) - F(A)| + \sum_{x \in X} |F(X) - F(B)|}{2}.$$

and where $\boldsymbol{A}$, $\boldsymbol{B}$, $\boldsymbol{C}$, $\boldsymbol{D}$, and $\boldsymbol{X}$ are blocks containing ends of candidate motion vectors, $\boldsymbol{X}$ being in the current field, $\boldsymbol{A}$ and $\boldsymbol{C}$ being in the previous field, and $\boldsymbol{B}$ and $\boldsymbol{D}$ being in the next field.

25. (Original) The interlace-to-progressive scan conversion system of claim 23, wherein a motion vector error correction function is defined by:

$$\overline{MV}(x,y,t) = \begin{cases} \begin{pmatrix} 0 \\ 0 \end{pmatrix}, & (e_m(x,y,t) \geq e_s(x,y,t)) \\ \overline{MV}(x,y,t), & (e_m(x,y,t) < e_s(x,y,t)) \end{cases}$$

where:

$$e_m(x,y,t) = \sum |F(C) - F(D)|$$

$$e_s(x,y,t) = \sum |F(A) - F(B)|$$

and where $\boldsymbol{A}$, $\boldsymbol{B}$, $\boldsymbol{C}$, $\boldsymbol{D}$, and $\boldsymbol{X}$ are blocks containing ends of candidate motion vectors, $\boldsymbol{X}$ being in the current field, $\boldsymbol{A}$ and $\boldsymbol{C}$ being in the previous field, and $\boldsymbol{B}$ and $\boldsymbol{D}$ being in the next field.

26. (Original) The interlace-to-progressive scan conversion system of claim 16, wherein a cost function is defined by:

$$\forall\ F(x,y,t) \in B(x,y,t):$$

$$D = \left| F(x,y,t) - F(x - MV_x, y - MV_y, t-1) \right|$$

$$TD = TD + D$$

$$Diff = D - EstErr$$

$$EstErr = EstErr + (\delta + Diff));$$

$$Dev = Dev + \delta\left(\left|Diff\right| - Dev\right)$$

27. (Original) The interlace-to-progressive scan conversion system of claim 16, wherein the block erosion sub-component divides each block according to:

$$B(x,y,t) = \{(x,y) \mid X_x - X/2 \le x \le X_x + X/2 \wedge X_y - Y/2 \le y \le X_y + Y/2\}$$

wherein a vector $\overline{MV}(x,y,t)$ is assigned, into four sub-blocks $B_{i,j}(x,y,t)$

$$B_{i,j}(x,y,t) = \left\{(x,y) \mid X_x - (1-i)\cdot\frac{X}{4} \le x \le X_x + (1+i)\cdot\frac{X}{4} \wedge X_y(1-j)\cdot\frac{Y}{4} \le y \le X_y + (1+j)\cdot\frac{Y}{4}\right\}$$

and wherein the variables *I* and *j* take the values +1 and –1; wherein a vector $MV_{i,j}(x, y, t)$ is assigned to the pixels of each of the sub-blocks $B_{i,j}(x, y, t)$:

$$\forall (x,y) \in B_{i,j}(x,y,t) : \overline{MV}_{i,j}(x,y,t) = \overline{MV}_{i,j}(\overline{X},t)$$

wherein:

$$\overline{MV}_{i,j}(\overline{X},t) = \mathrm{med}\left[\overline{MV}(x + i\cdot X, y, t), \overline{MV}(\overline{X},t), \overline{MV}(x, y + j\cdot Y, t)\right]$$

wherein the median function is a median on the *x* and *y* vector components separately;

and

wherein a resulting vector is replaced by an original motion vector unless the resulting vector is equal to one of the three input vectors.

28. (Original) The interlace-to-progressive scan conversion system of claim 16, wherein the first stage selection function is given by:

$$F_n(x,y,t)=\begin{cases}F(x+MV_x(x,y,t),y+MV_y(x,y,t),t+1), & (D_m<D_s)\\ F(x,y,t+1), & (D_m\geq D_s)\end{cases}$$

where:

$$D_s=\sum_{k=-2}^{2}C_v(k)\cdot\left|F(x,y+k,t)-F(x,y+k,t+1)\right|$$

$$D_m=\sum_{k=-2}^{2}C_v(k)\cdot\left|F(x,y+k,t)-F(x-MV_x(x,y,t),y-MV_y(x,y,t)+k,t+1)\right|$$

(3.22)

29. (Original) The interlace-to-progressive scan conversion system of claim 16, wherein the third stage combining function is given by:

$$F_o(x,y,t)=\begin{cases}F(x,y,t), & (y \bmod 2=t \bmod 2)\\ (c_i\cdot F_i(x,y,t))+(1-c_i)(c_p\cdot F_p(x,y,t)+(1-c_p)F_n(x,y,t)), & (\text{otherwise})\end{cases}$$

wherein c_i and c_p are adaptive coefficients ranging from 0 to 1; F_n is given by:

$$F_n(x,y,t)=\begin{cases}F(x+MV_x(x,y,t),y+MV_y(x,y,t),t+1), & (D_m<D_s)\\ F(x,y,t+1), & (D_m\ge D_s)\end{cases}$$

wherein intra-field interpolation is given by:

$$F_i(x,y,t)=\frac{F(x,y-1,t)+F(x,y+1,t)}{2}$$

and wherein backward data prediction is given by:

$$F_p(x,y,t)=F(x-MV_x(x,y,t),y-MV_y(x,y,t),t-1)$$

30. (Original) An interlace-to-progressive scan conversion system, comprising:

a spatial line averaging prefilter having a prefiltered signal as an output;

a motion estimator having the prefiltered signal as input and a motion-corrected signal as an output, the motion estimator comprising:

a 3-D recursive search sub-component having a bilinear interpolator;

a motion vector correction sub-component having an error function, the error function including penalties related to a length of the difference vector between a given candidate vector and a plurality of neighboring vectors;

a block erosion sub-component;

wherein the motion estimator assumes that a motion vector for an object between a previous field and a current field is the same as a motion vector for the object between the current field and a next field

a three-stage adaptive recursive filter having the prefiltered output and the motion-corrected output as inputs, the three stages comprising:

a first stage that comprises a function that selects between using static pixels data and moving pixels data from a next field;

a second stage that comprises a function that selects a more valid set of data between motion compensated data from a previous field and the pixels selected by the first stage; and

a third stage that comprises a function that combines an intra-field interpolation with the more valid set of data selected by the second stage.

31. (Original) An interlace-to-progressive scan conversion system, comprising:

a spatial line averaging prefilter having a prefiltered signal as an output;

a motion estimator having the prefiltered signal as input and a motion-corrected signal as an output, the motion estimator comprising: a 3-D recursive search sub-component; a motion vector correction sub-component; and a block erosion sub-component; wherein:

the 3-D recursive search sub-component includes a bilinear interpolator defined by:

$$
\begin{aligned}
F(x,y,t) = {} & (yf \cdot xf \cdot F(xi,yi,t)) + (yf \cdot (1-xf) \cdot F(xi+1,yi,t)) + \\
& ((1-yf) \cdot xf \cdot F(xi,yi+1,t)) + ((1-yf) \cdot (1-xf) \cdot F(xi+1,yi+1,t)
\end{aligned}
$$

where:

$$yf = \lfloor y \rfloor \qquad xf = \lfloor x \rfloor \qquad (3.4)$$

and:

$$yi = y - \lfloor y \rfloor \qquad xi = x - \lfloor x \rfloor \qquad (3.5)$$

and wherein a value of a first estimator is set to a value of a second estimator if:

$$e(\overline{MV}_a, \overline{X} - \overline{SMV}_a, t) > e(\overline{MV}_b, \overline{X} - \overline{SMV}_b, t) + Th$$

and wherein the value of the second estimator is set to the value of the first estimator if:

$$e(\overline{MV}_b, \overline{X} - \overline{SMV}_b, t) > e(\overline{MV}_a, \overline{X} - \overline{SMV}_a, t) + Th$$

where Th is a fixed threshold;

the 3-D recursive search sub-component has a look-up table consisting of:

$$US_n = \left\{ \begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 0 \\ 1 \end{pmatrix}, \begin{pmatrix} 0 \\ -1 \end{pmatrix}, \begin{pmatrix} 1 \\ 0 \end{pmatrix}, \begin{pmatrix} -1 \\ 0 \end{pmatrix}, \begin{pmatrix} 0 \\ 2 \end{pmatrix}, \begin{pmatrix} 0 \\ -2 \end{pmatrix}, \begin{pmatrix} 3 \\ 0 \end{pmatrix}, \begin{pmatrix} -3 \\ 0 \end{pmatrix}, \begin{pmatrix} 0 \\ \frac{1}{4} \end{pmatrix}, \begin{pmatrix} 0 \\ -\frac{1}{4} \end{pmatrix}, \begin{pmatrix} \frac{1}{4} \\ 0 \end{pmatrix}, \begin{pmatrix} -\frac{1}{4} \\ 0 \end{pmatrix} \right\}$$

a motion vector correction sub-component having an motion vector error correction function defined by:

$$\overline{MV}(x,y,t) = \begin{cases} \begin{pmatrix} 0 \\ 0 \end{pmatrix}, & \left(e_m(x,y,t) \geq e_s(x,y,t)\right) \\ \overline{MV}(x,y,t), & \left(e_m(x,y,t) < e_s(x,y,t)\right) \end{cases}$$

where:

$$e_m(x,y,t) = \sum |F(C) - F(D)|$$

$$e_s(x,y,t) = \sum |F(A) - F(B)|$$

and where $\boldsymbol{A}$, $\boldsymbol{B}$, $\boldsymbol{C}$, $\boldsymbol{D}$, and $\boldsymbol{X}$ are blocks containing ends of candidate motion vectors, $\boldsymbol{X}$ being in the current field, $\boldsymbol{A}$ and $\boldsymbol{C}$ being in the previous field, and $\boldsymbol{B}$ and $\boldsymbol{D}$ being in the next field.

a block erosion sub-component that divides each block according to:

$$B(x,y,t) = \{(x,y) \mid X_x - X/2 \le x \le X_x + X/2 \wedge X_y - Y/2 \le y \le X_y + Y/2\}$$

wherein a vector $\overline{MV}(x,y,t)$ is assigned, into four sub-blocks $B_{i,j}(x,y,t)$

$$B_{i,j}(x,y,t) = \left\{(x,y) \mid X_x - (1-i)\cdot\frac{X}{4} \le x \le X_x + (1+i)\cdot\frac{X}{4} \wedge X_y (1-j)\cdot\frac{Y}{4} \le y \le X_y + (1+j)\cdot\frac{Y}{4}\right\}$$

and wherein the variables I and j take the values +1 and –1; wherein a vector $\boldsymbol{MV}_{i,j}(x, y, t)$ is assigned to the pixels of each of the sub-blocks $B_{i,j}(x, y, t)$:

$$\forall(x,y) \in B_{i,j}(x,y,t) : \overline{MV}_{i,j}(x,y,t) = \overline{MV}_{i,j}(\overline{X},t)$$

wherein:

$$\overline{MV}_{i,j}(\overline{X},t) = \text{med}\left[\overline{MV}(x + i\cdot X, y, t), \overline{MV}(\overline{X},t), \overline{MV}(x, y + j\cdot Y, t)\right]$$

wherein the median function is a median on the x and y vector components separately; and

wherein a resulting vector is replaced by an original motion vector unless the resulting vector is equal to one of the three input vectors.

a three-stage adaptive recursive filter having the prefiltered signal and motion-corrected signals as output, the three stages comprising:

a first stage comprises a function that selects between using static pixels data and moving pixels data from a next field according to the function:

$$F_n(x,y,t) = \begin{cases} F(x+MV_x(x,y,t), y+MV_y(x,y,t), t+1), & (D_m < D_s) \\ F(x,y,t+1), & (D_m \geq D_s) \end{cases}$$

where:

$$D_s = \sum_{k=-2}^{2} C_v(k) \cdot \left| F(x,y+k,t) - F(x,y+k,t+1) \right|$$

$$D_m = \sum_{k=-2}^{2} C_v(k) \cdot \left| F(x,y+k,t) - F(x-MV_x(x,y,t), y-MV_y(x,y,t)+k, t+1) \right|$$

a second stage comprises a function that selects a more valid set of data between motion compensated data from a previous field and the pixels selected by the first stage; and

a third stage comprises a function that combines an intra-field interpolation with the more valid set of data selected by the second stage according to the function:

$$F_o(x,y,t)=\begin{cases} F(x,y,t), & (y \bmod 2 = t \bmod 2) \\ (c_i \cdot F_i(x,y,t)) + (1-c_i)(c_p \cdot F_p(x,y,t) + (1-c_p)F_n(x,y,t)), & (\text{otherwise}) \end{cases}$$

wherein c_i and c_p are adaptive coefficients ranging from 0 to 1; F_n is given by:

$$F_n(x,y,t)=\begin{cases} F(x+MV_x(x,y,t), y+MV_y(x,y,t), t+1), & (D_m < D_s) \\ F(x,y,t+1), & (D_m \geq D_s) \end{cases}$$

wherein intra-field interpolation is given by:

$$F_i(x,y,t)=\frac{F(x,y-1,t)+F(x,y+1,t)}{2}$$

and wherein backward data prediction is given by:

$$F_p(x,y,t)=F(x-MV_x(x,y,t), y-MV_y(x,y,t), t-1)$$

32. (Original) A method for converting an interlaced image to a progressive scan image, the method comprsing:

providing an input signal corresponding to an image;

prefiltering the input signal with a spatial line averaging prefilter;

estimating motion in the image by:

performing a 3-D recursive search;

performing a motion vector correction;

performing a block erosion to reduce blockiness in the progressive scan image;

filtering the signal in three stages:

in the first stage selecting between using static pixels data and moving pixels data from a next field;

in the second stage selecting a more valid set of data between motion compensated data from a previous field and the pixels selected by the first stage; and

in the third stage combining an intra-field interpolation with the more valid set of data selected by the second stage.

33. (Original) A method for converting an interlaced image to a progressive scan image, the method comprsing:

providing an input signal corresponding to an image;

prefiltering the input signal with a spatial line averaging prefilter;

estimating motion in the image by:

assuming that a motion vector for an object between a previous field and a current field is the same as a motion vector for the object between the current field and a next field;

performing a 3-D recursive search;

performing a motion vector correction in which the error function penalizes a candidate vector based on a length of a difference

vector between the candidate vector and a plurality of neighboring vectors;

performing a block erosion to reduce blockiness in the progressive scan image;

filtering the signal in three stages:

in the first stage selecting between using static pixels data and moving pixels data from a next field;

in the second stage selecting a more valid set of data between motion compensated data from a previous field and the pixels selected by the first stage; and

in the third stage combining an intra-field interpolation with the more valid set of data selected by the second stage.